the only feasible commercial method of separating fatty acids by chain length. Higher technology, such as chromatographic types of separation, remains to be developed to eliminate this manufacturing step which is a large consumer of energy.

–Improved hydrogenation catalysts is another example of a desirable advance in oleochemical technology.

–Development of new specialty oilseeds is a challenge for the industry which will have to be met in cooperation with agronomists, farmers and others.

–The high cost of meeting environmental requirements makes it necessary to work toward zero discharge of process waters. A lot has been accomplished but this is an area where a great deal more still remains to be done.

These are only a few of the numerous challenges for our research and development people. The successes of the researchers will probably play the biggest role of all in the future marketing and economics of the companies in the fatty chemical industry.

Profitability

The fifth and final category of challenges is profitability. Although no financial statements are available for public scrutiny, it is believed that the fatty chemical industry has had difficulty in consistently maintaining acceptable return on either equity or investment. This belief is given some credibility for fatty acids, in particular, by the reduced number of companies selling these products in the merchant market.

The overall challenge facing the oleochemical industry currently is twofold. First, how do you avoid the possiblity of extinction? and second, how do you achieve a reasonable rate of return on investment in a mature industry? The answer, we believe, lies in three common characteristics of business strategies which have succeeded in mature industries: growth segments within the industry are identified or created and then exploited; product quality and innovative product improvement are emphasized; and production and distribution efficiencies are systematically improved. In our business in the USA, this probably means fewer, more efficient, fatty acid producers and should mean a higher percentage of the sales dollar spent on research and development for processing improvement and innovation in applications.

REFERENCES

1. Aldag, C., Talk to the CMRA, New York, May 1975.
2. Eur. Chem. News, November 15 (1982).

Marketing and Economics of Fatty Alcohols

COLIN A. HOUSTON, Colin A. Houston & Associates, Inc., PO Box 416, Mamaroneck, NY 10543

ABSTRACT

Alcohols represent 35% of the world's major surfactant intermediates, with natural alcohols accounting for one-third of that percentage. Present trends suggest, however, that alcohols will become increasingly important in the detergent industry (the primary market for surfactants) during the next 10 years. Moreover, natural alcohols will frequently have an economic advantage over synthetics. Factors contributing to the growth of alcohols as surfactant intermediates include: better derivative biodegradability (especially compared to alkylbenzenes), better solubility (for use in low-temperature washing and in liquid detergents), better hard-water tolerance (for use in unbuilt liquid detergents), and a reputation for better detergency on synthetic fabrics. Factors favoring the natural alcohols (as opposed to the synthetics) include: frequently favorable raw material economics (especially as supplies of lauric oils increase), and integration of major manufacturers.

The primary outlet for the world's fatty alcohols is the highly competitive surfactant intermediate market. In this industry, natural and synthetic alcohols compete with linear and branched alkylbenzenes for market position. In 1982, free world production of major surfactants was 65% alkylbenzenes, 21% synthetic alcohols and 14% natural alcohols. The current question is, "How far can the alcohols (and especially the natural alcohols) go toward turning this situation around so that they are produced in larger volumes than alkylbenzenes?"

Total world production of these intermediates is ca. 2 million tons. If this 2 million tons were all converted to surfactant derivatives–linear and branched alkylbenzene sulfonates, alcohol sulfates, ethoxylates and ethoxysulfates –and converted to cleaning products, the yield would be over 20 million tons of finished detergents. There are other intermediates of importance, such as the alkylphenols, but upwards of 80% of the intermediate volume is concentrated in the products shown here.

Of these major surfactant intermediates, 70% of the volume is consumed by the household detergent industry, so I will focus on that industry. The three workhorse products of the detergent industry–53% heavy-duty powders, 3% heavy-duty liquids and 17% light-duty liquids–can all be made using either alcohol-based surfactants, alkylbenzene-based products, or combinations of both. The manufacturer's choice among these intermediates will be based on cost and performance considerations.

Along with cleaning power, biodegradability is a performance factor that must be considered carefully. It is difficult to assess biodegradability with a cost/performance equation, but we do need to comply with pollution regulations. Alcohol derivatives show better biodegradability than linear alkylbenzenes, and much better than the branched alkylbenzene derivatives.

The high volume natural alcohols are made from three natural fats or oils. Natural C_{12-14} alcohols usually come either from coconut oil or palm kernel oil, both of which are now in the 45¢/lb range. When the higher C_{16-18} range is sought, the feedstock used is now tallow, now approaching 20¢/lb. (These prices are as of the beginning of September, 1983.) Of course, many other oils can be and are used to produce lower volume alcohols, but today we are concentrating on the bulk, the highest volume products, since they are the key to alcohol industry economics.

Natural alcohol production processes yield potentially valuable byproducts. The fat or oil is first processed to fatty acids or methyl esters, either of which may be sold directly. The processes also yield glycerine.

The natural alcohol producer has great flexibility in that he can vary his costs and his products by selection of feedstock. Natural fats and oils yield acids and methyl esters (and hence derivative alcohols) in a fixed ratio of chain lengths. The natural alcohol producer must give careful consideration to coproduct economics when selecting his feedstock. For example, the yield from both coconut and palm kernel oil (Fig. 1) centers at C_{12}. But coconut oil yields more $C_{8\text{-}10}$ coproducts, whereas palm kernel yields more C_{18}. Obviously, the producer must carefully consider the value of these coproducts when deciding which oil to use. His decision will be difficult, since coproduct values can fluctuate widely in a short time span.

In addition to having different chain length distributions, various natural oils also have different degrees of unsaturation. By using certain catalysts to preserve the double bond, unsaturated alcohols may be derived from these oils. This can help to improve overall plant utilization. Another way in which a sufficiently integrated producer can sometimes mitigate the coproduct constraints imposed by feedstocks is by downstream processing to alternative derivatives such as amines.

Synthetic fatty alcohols are based almost entirely on ethylene or *n*-paraffins, as shown in Figure 2. In Europe, ethylene today is 25-26¢/lb, and *n*-paraffins in the $C_{11\text{-}14}$ range are just under 25¢/lb. (These are June 1983 prices; US prices are slightly lower.) Synthetic alcohol manufacturing process technology has the advantage that production can be peaked at desired chain lengths, albeit at the expense of additional processing cost. Synthetic alcohol manufacture does not involve marketable fatty acids or methyl esters as does natural manufacturing. Integrated oxo process manufacturers can and do also market intermediate olefins.

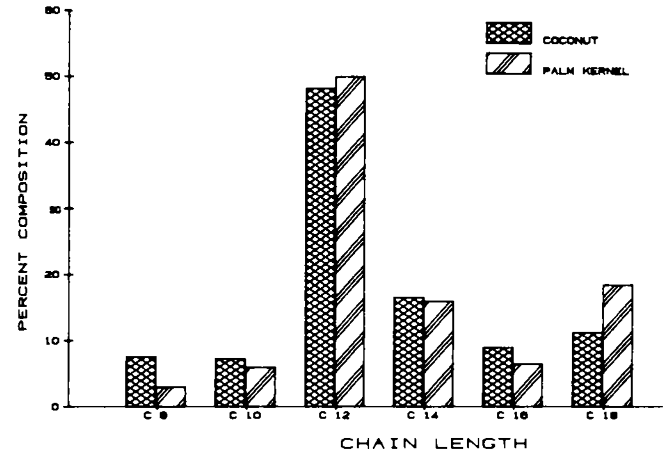
Branched alkylbenzenes are made from propylene and benzene, as shown in Figure 3. Linear alkylbenzene uses linear olefins—produced from either *n*-paraffins, or from ethylene—and benzene. Propylene in Europe is 17¢/lb, and benzene is 19¢/lb. (Again, these are June 1983 prices, and US prices vary somewhat.) Both types of alkylbenzenes have traditionally had an advantage over alcohols in production and raw material costs.

From a look at historical prices (Fig. 4), some very important observations can be made. For simplicity, the *n*-paraffin line has been omitted from this chart, but *n*-paraffins track ethylene rather closely.

For the first time in 1982, coconut, palm kernel and tallow prices all fell below petrochemical prices. This caused suppliers and buyers throughout the world to become highly optimistic about the future of the natural feedstocks. But looking at the coconut/palm kernel line particularly, we can see that natural oil prices have oscillated widely and unpredictably over the past 10 years, a fact which has caused chemically oriented buyers to regard these products with great caution. And now in 1983, when coconut and palm kernel oil prices have risen as much as 100% in 6 months, it is evident that natural oil prices are still subject to volatility.

There should, however, be mitigating factors to dampen such swings in the future. As shown in Figure 5, production of palm and palm kernel oil promises to continue to increase rapidly, due to improved agricultural and biological techniques. Forecasts to 1990 are that palm oil production will nearly double to almost 10 million tons. The sheer bulk of palm oil production should result in lower and more stable oil prices.

Even greater lauric supply increases should come in the future, with further use of biotechnology and the introduction of new planting materials such as cuphea, a highly adaptable plant which can be grown in a variety of climates.



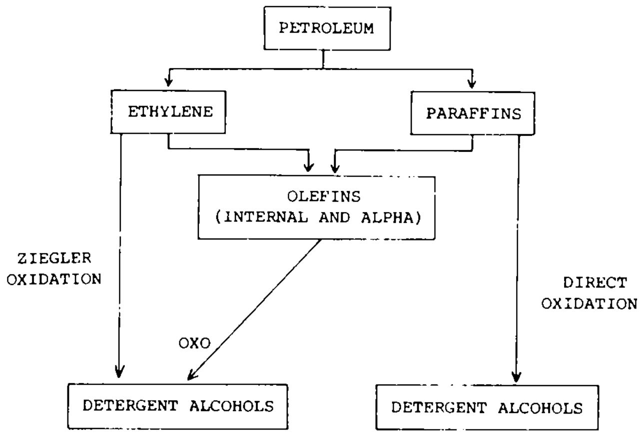


FIG. 2. Production of synthetic alcohols.

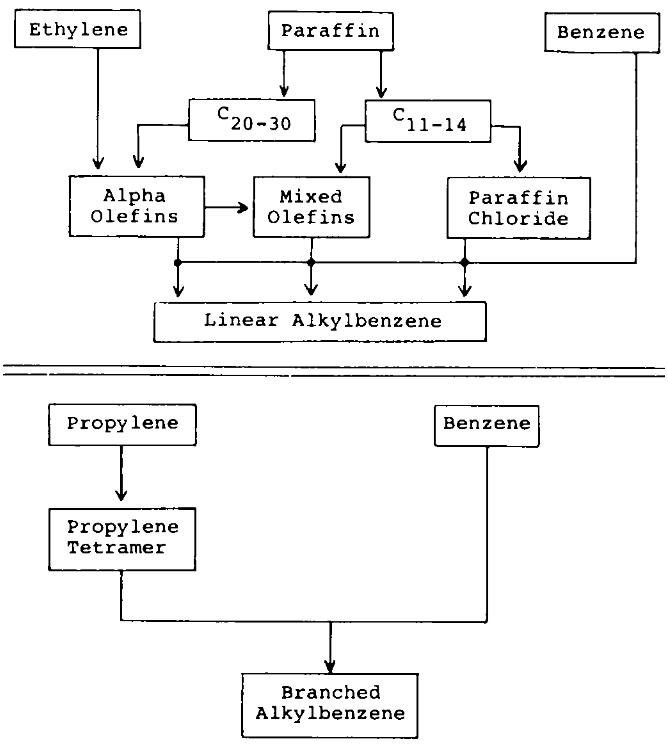


FIG. 3. Production of alkylbenzenes.

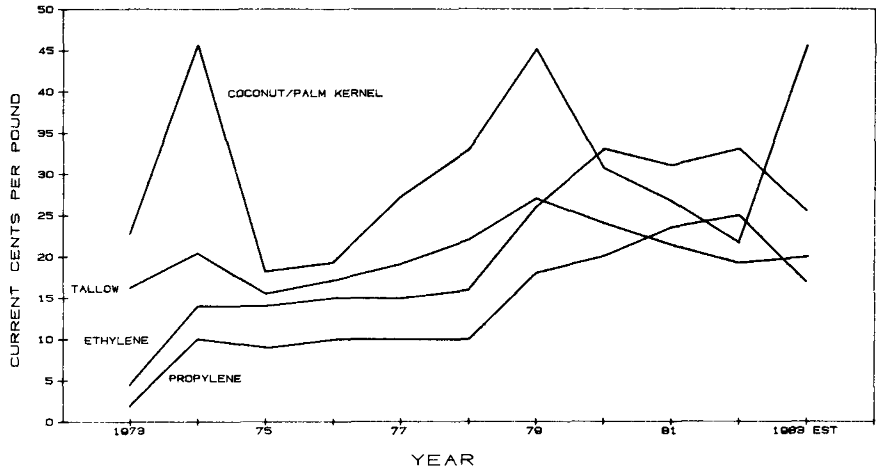


FIG. 4. Price history: natural and petrochemical raw materials.

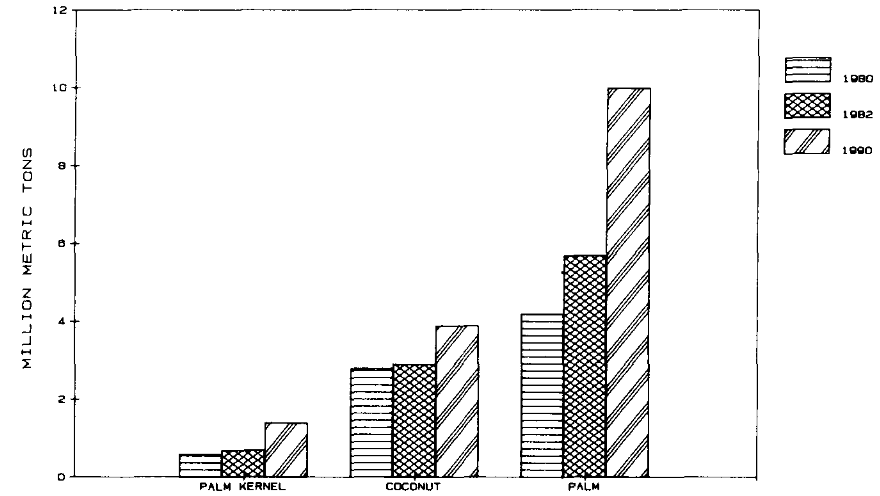


FIG. 5. World production of selected natural oils.

Using mutagenic techniques, cuphea strains have been developed whose seeds contain 50% oil, almost 90% of that oil being in the C_{10-12} range. Yields have reached 2 metric tons/hectare.

Synthetic alcohol feedstock prices, meanwhile, have lost some of their past stability. At any time, an upset in the political situation in the Middle East can radically affect these prices. The official price of OPEC crude oil, though presently stable, rose from 0.6¢/lb in 1972 to 10.5¢/lb in 1981. Now, if we chart crude oil prices vs ethylene and benzene (Fig. 6), we see a curious thing. Prior to 1981, ethylene and benzene prices were rising at a rate comparable to or even greater than the rate of crude oil prices. Since 1981, benzene and especially ethylene prices have recently been falling faster than crude oil prices. But how long can this situation prevail? The ethylene producers' profits are presently nonexistent, and many plants are being shut down, at some point this situation must turn around. Although new ethylene derivative production in countries such as Canada and Saudi Arabia will keep a damper on price increases, this is a potentially upwardly volatile price situation.

In the long term, as petroleum gets scarce, there can be little doubt that natural alcohols are going to become increasingly attractive economically. But for the more immediate future the picture is far less certain. Another look at Figure 4 on raw material price evolution shows that vegetable oil prices have risen to unusual heights on several occasions: once from mid-1973 to mid-1974, again from 1978 to mid-1979, and again at present. In all, vegetable oil prices have spent perhaps 30% of the past 10 years in ranges that are beyond the bounds of economic feedstock viability. It is probably safe to assume that they will spend a similar percentage of the next 10 years at unacceptable levels.

Still, this means that 70% of the time, the prices of natural oils will be favorable. And there have already been clear indications of what the results of this development will be for the alcohol industry.

Figure 7 shows what happened to natural and synthetic alcohol production as raw material prices reached their low point in 1982. Clearly, natural alcohol production has grown at the expense of synthetic alcohol during the past 3 years. In Asia, which has relatively high cost petrochemical feedstocks and good access to natural oils, the trend has been most marked. In the USA and Western Europe, the trend is less pronounced.

Along with this increase in natural alcohol production has come a rise in natural alcohol capacity between 1980 and 1983, as shown in Table I. This is indicative of the optimism generated by falling natural raw material prices. Note that in North America, 95% of the 1983 capacity belonged to Procter & Gamble; in Europe, 65% belonged to Henkel; and in Asia, 25% belonged to Kao Soap. Only these

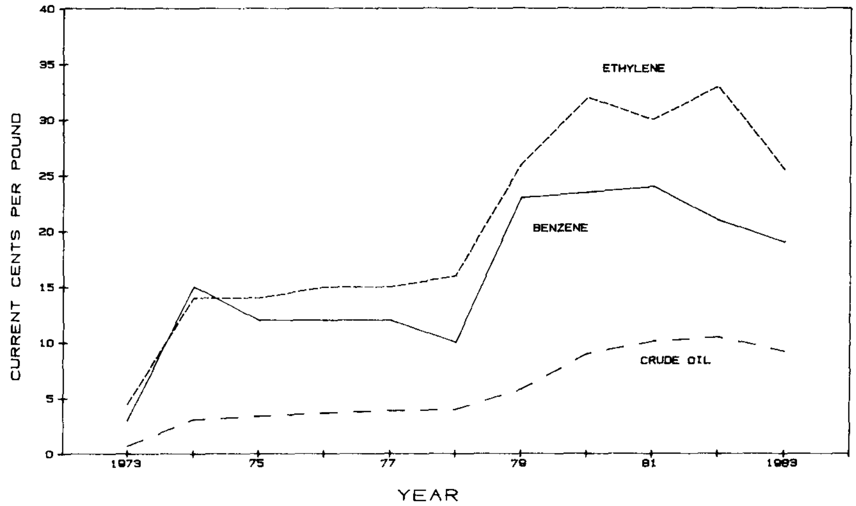


FIG. 6. Price evolution: crude oil vs ethylene, benzene.

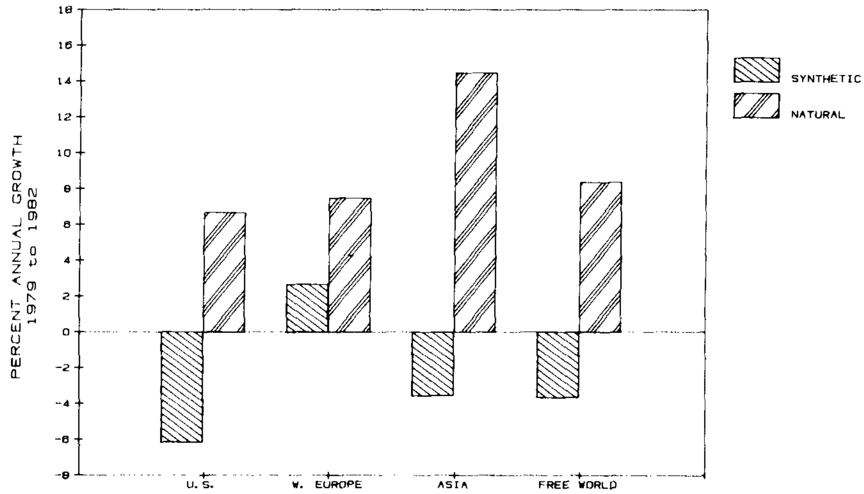


FIG. 7. Growth of free world fatty alcohol production.

TABLE I

Free World Producers of Natural Alcohols C_8 and Higher (thousand metric tons)

Country	Company	1980	1983
USA	Procter & Gamble		
	Cincinnati, OH	11	30
	Kansas City, MO	45	45
	Sacramento, CA	57	85
	Sherex	5	5
		118	165
Western Europe			
West Germany	Henkel	95	150
	Condea Chemie	30	30
United Kingdom	Marchon Div. of A&W (Tenneco)	25	25
France	Sidobre-Sinnova (Henkel)	25	25
Denmark	Aarhus	3	3
		178	233
Asia			
Japan	Kao Soap	15	15
	New Japan Chemical Co.	15	15
	Daichi Kogyo Seiyaku	2	2
	Kyowa Fat & Oil	6	6
	Nikka Chemical	1	1
Philippines	Philipinas Kao	20	20
	UNICHEM	–	30 (1985)
India	Aegis Chemical	5	5
	Atul Chemical	–	3
		64	97
	Grand total	360	495

TABLE II

Integration Profile of Important Detergent-Related Companies

Detergent-related manufacturer	Petroleum raw producer	Soap producer	Fatty acid producer	Builder supplier	LAB producer	EO producer	Alcohol producer	Seller of national brand detergents at retail
P&G		X	X				X	X
Henkel		X	X	X			X	X
Kao Soap		X	X				X	X
Albright & Wilson	X			X			X	
BASF	X				X	X	X	
Chimica Augusta (Anic)	X				X	X	X	
Colgate		X						X
Conoco (DuPont)	X				X		X	
Ethyl Corp.				X			X	
ICI	X					X	X	
Lever		X	X	X				X
Lion Oil		X	X					X
Shell Chemical	X				X	X	X	

three companies are integrated through to the detergent consumer; and this integration, along with their size, makes them extremely potent competitors.

Table II shows the presence of Procter & Gamble, Henkel and Kao in the fatty acid, soap, alcohol and detergent end-markets. This integration gives them great strength for profitably making or buying alcohols and extracting the maximum profit from the key by- and coproducts such as fatty acids and glycerine.

There is little need now for additional natural alcohol producers; barely half of the existing capacity is being used. But some companies with special geographical or coproduct advantages may enter this field. Strong pressure to build natural alcohol plants exists in the Far East, where fat splitting capacity far exceeds demand. These fat splitters may well turn to alcohol as a way of opening up an additional market. European fat splitters are already under economic pressure, and the pressure will be increased as the Far East producers try to penetrate the European fatty acid markets. Some of the European fatty acid producers may therefore elect to integrate a step forward into alcohol. All such new entrants, however, will have to move their products against the 40% overcapacity of the existing, well positioned natural alcohol producers.

Meanwhile, the capacities of the synthetic alcohol producers (Table III) remained constant between 1980 and 1983, and no expansions are foreseen for the next few years. None of these producers are integrated through to the consumer, making their business in this respect less secure. In times of shortage or high natural oil prices, the integrated natural alcohol producers can buy synthetics to fill out their own production; but in times of low natural oil prices the integrated alcohol producers will cut back on outside purchases. It is unlikely that there will be new synthetic alcohol plants because of the present 40% overcapacity and the existing economic uncertainties.

So much for the supply side of the alcohol business, and the issue of production economics. Let us now look briefly at the detergent end-market for fatty alcohols and the issue of performance. There is an intercompetition between synthetic and natural alcohols and the alkylbenzenes in the detergent market. Given broadly equal prices for all surfactant derivatives, recent trends in detergent formulation (especially the introduction of heavy-duty liquids) have favored the alcohols. Figure 8 illustrates the swing toward liquids in the United States.

Phosphate legislation, higher energy costs (encouraging lower wash temperatures) and increased use of synthetic fabrics started a trend towards liquid detergents in the late 1960s and early 70s. These factors also encouraged a trend toward alcohol derivatives, which some formulators believe have performance advantages under the new conditions.

TABLE III

Free World Producers of Synthetic Alcohols, 1982: C_{12} and Higher

Country	Company	Capacity (thousand metric tons)
USA	Shell	250
	Conoco	60
	Ethyl	100
	Exxon	20
		430
Western Europe		
West Germany	Condea	35
	Ruhrchemie	6
	BASF	25
	Huels	2
United Kingdom	Shell	40
	ICI	20
France	PCUK	10
Italy	Chemica Augusta	40
		178
Far East		
Japan	Mitsubishi Chemical	7
	Mitsubishi Petrochemical	30
	Nissan Chemical	10
	Nippon Shokubai	18
		65
	Grand total	673

Although one important US heavy-duty liquid is a built product (originally utilizing pyrophosphate, later sodium citrate), most heavy-duty liquids in the USA are now unbuilt combinations of anionic and nonionic surfactants. A typical formulation would have 13-14% linear alkylbenzene sulfonate (LABS), 19-20% alcohol ethoxylate and q.s. with water or alcohol.

Such unbuilt detergents must depend for effectiveness on relatively high levels of surfactant, and one of their selling points is good performance in lower temperature washing. These factors favor the use of alcohol-based surfactants, because they have very good solubility, and also because hardness (calcium and magnesium ions) is less detrimental to the washing performance of the alcohol-

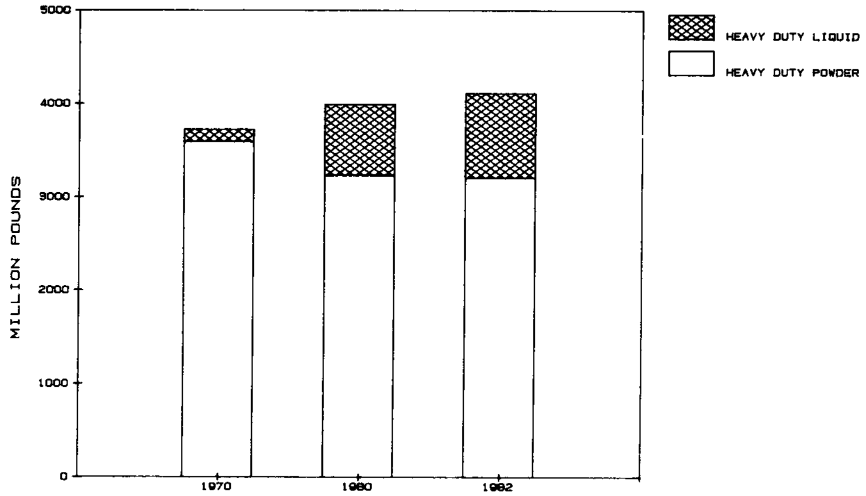


FIG. 8. United States trends in powder vs liquid heavy-duty detergents.

based surfactants than to that of LABS.

The total household powder and liquid market continues to grow, albeit at a low rate of 1-2% per year. Alkylbenzenes are static in the USA, but the alcohols have been able to increase their market share. This trend is expected to continue.

The market continues to evolve, further complicating the selection of surfactant systems. The introduction of enzymes in heavy-duty liquids, and the inclusion of wash cycle fabric softeners, are two progressing product developments that tend to favor alcohol-derived surfactants. Increased raw material costs and pressure to maintain prices at the consumer level breed a fiercely competitive environment.

All of the factors discussed in this presentation indicate that detergent alcohols, and natural alcohols especially, have a bright future in store. The important points in favor of the alcohols are a raw material base that can be opportunistically shifted between petroleum and natural oils, excellent biodegradability and excellent performance in detergent applications under today's conditions.

Marketing and Economics of Oleochemicals to the Oil Patch

C.D. LaSUSA Jetco Chemicals, Inc., PO Box 1898, Corsicana, TX 75110

ABSTRACT

Oleoamines represent the largest class of oleochemicals used in the oil patch and are used in virtually all phases of the oil industry. Although the largest volume is used in production and refining, many amines are used prior to production in drilling operations and well completions, as well as postprocessing as additives in finished products. Other oleochemicals widely used include various surfactants made by ethoxylation and sulfation of fatty acids as well as polymerized fatty acids. The amines of interest start with simple primary amines and include secondary, tertiary and quaternary amines. They extend into higher amines such as diamines, triamines and beyond as well as all of these further reacted with other chemical species. Oleoamines in a generic sense also include amino amides, amphoteric amines, cyclic amidines, ether amines, as well as some high molecular weight polymeric materials. The oleoamines are used per se in suitable solvent systems, or as components in a wide variety of finished products containing several chemical entities to obtain specified product properties. Oleoamines, their derivatives, and other oleochemicals are used to prevent corrosion, inhibit and kill bacteria, condition waters for improved injectivity, emulsify, deemulsify, foam, gel, remove deposits, disperse solids, wet solids, solubilize or disperse otherwise incompatible liquids, produce or stabilize foaming systems, lubricate and produce detergent properties in liquid systems. They are used in drilling fluids. well completion fluids, oil and gas wells, water source wells, injection wells, gathering systems, filters, storage tanks, pipelines, refineries, and in finished products for all of the purposes listed above. This paper covers the oil patch operating parameters that determine the need for using oleochemicals, and describes for each system appropriate oleochemicals whose properties satisfy those needs.

The "oil patch" is not one industry, but many. Generally, the applications are grouped into three general areas: exploration, production and refining. This discussion will begin with the drilling of the well and take the reader through numerous steps necessary to obtain finished refined products.

OIL AND GAS WELL DRILLING

Oil Muds

A high-grade Wyoming bentonite is reacted with a quaternary ammonium chloride made from methyl dihydrogenated tallow amine. Bentonite, by nature a water-swelling clay, is converted to an oil-swelling mixture. This product is the basic component for many oil muds.

Historically, the oil mud market has been only 10% of the total market. Due to the economics, water-base muds have had a 90% market share. Recent surveys of major oil companies and major mud companies indicate that oil mud usage is increasing and may eventually become a 30% factor in the total market. The reasons for this increase in market are as follows.

Deep drilling. Oil muds are more heat-stable, thus find a larger application as deeper drilling becomes more prevalent. The extent of deep drilling appears to have established a trend. Deep wells, 15,000 ft or below, accounted for a 400-600 well average during the late 1970s. This figure